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54 Portable radio communication apparatus having diversity reception function.

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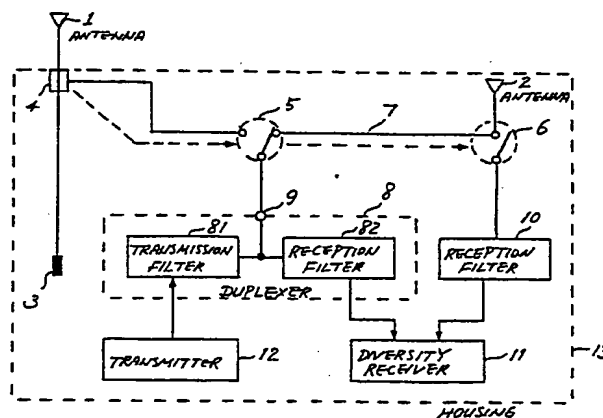


Fig. 2A

## Description

### PORTABLE RADIO COMMUNICATION APPARATUS HAVING DIVERSITY RECEPTION FUNCTION

#### BACKGROUND OF THE INVENTION

The present invention relates to a portable radio communication apparatus and, more particularly, to a portable radio communication apparatus having a diversity reception function.

An example of portable radio communication apparatuses of the type described is disclosed in "No. 2455: Study on a Diversity Antenna for Portable Radio Unit" by Taga et al, National Convention (Record) of the Institute of Electronics and Communication Engineers of Japan, pp. 10 - 155, 1984. The communication apparatus shown and described in this paper includes two folded inverted F-type antennas which are built in a housing, so that diversity reception may be performed through those antennas. Although such a construction is suitable for portable apparatus design, it fails to achieve a required sufficient degree of antenna gain.

A portable radio communication apparatus capable of attaining a sufficient gain is disclosed in "PORTABLE RADIO," Japanese unexamined laid-open patent application No. Shô 62-49729, namely 49729 of 1987 (the corresponding United States patent application Ser. No. 897,989; European patent application Ser. No. 86306575.1; Canadian patent application Ser. No. 516,870-8; and Australian patent application Ser. No. 61837/86) which is invented by Hashimoto et al and assigned to the applicant of the instant application. As will be described in detail later, this apparatus is provided with a single sleeve or whip antenna and a single built-in antenna for effecting diversity reception. The sleeve or whip antenna is connected to a transmitter and a diversity receiver while the built-in antenna is connected to the diversity receiver. The sleeve or whip antenna may be tucked away in a housing to enhance portability. So long as the apparatus is used with the sleeve or whip antenna pulled out of the housing, sufficiently high reception and transmission gains are guaranteed due to the high antenna gain and diversity gain of the sleeve or whip antenna. However, once the sleeve or whip antenna is received or plunged in the housing, the transmitter becomes substantially inoperable to render bidirectional communication impracticable.

#### SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an improved portable radio communication apparatus having a diversity reception function.

It is another object of the present invention to provide a portable radio communication apparatus having a diversity reception function which achieves a sufficiently high reception gain.

It is another object of the present invention to provide a portable radio communication apparatus having a diversity reception function which is capable of transmitting even when a sleeve or whip antenna is received in a housing or folded.

In accordance with the present invention, there is

provided a portable radio communication apparatus comprising transmitter means, diversity receiver means, transmission filter means connected to the transmitter means, first and second reception filter means connected to the diversity receiver means, first antenna means capable of being received in a housing of the apparatus, second antenna means mounted inside of or on outer periphery of the housing, and switch means for connecting the second antenna means to a junction of the transmission filter means and first reception filter means in a first condition in which the first antenna means is received in the housing, and connecting the first antenna means to the junction and the second antenna means to the second reception filter means in a second condition in which the first antenna means is pulled out of the housing.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken with the accompanying drawings in which:

Fig. 1 is a schematic block diagram showing a prior art portable radio communication apparatus having a diversity reception function for facilitating an understanding of the present invention;

Figs. 2A and 2B are schematic block diagrams of a portable radio communication apparatus having a diversity reception function embodying the present invention, in two different conditions;

Figs. 3A and 3B are schematic block diagrams of an essential part of a portable radio communication apparatus according to another embodiment of the present invention; and

Fig. 4 is a schematic view of a specific construction of a switch driving mechanism which is included in the apparatus as shown in Figs. 2A and 2B or 3A and 3B; and

Figs. 5 to 7 are schematic views showing specific structures for receiving and folding a sleeve and a whip antenna.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

To better understand the present invention, a brief reference will be made to a prior art radio communication apparatus, shown in Fig. 1. As shown, the apparatus includes an antenna 14 which is connected to a transmitter 12 and a diversity receiver 11 through, respectively, a transmission filter 81 and a reception filter 82 which are built in a duplexer 8. An antenna 15 is connected to the diversity receiver 11 through a reception filter 10. The antenna 14 is implemented with a sleeve antenna or a  $\lambda/2$  whip antenna which has a high radiation gain and allows a minimum of high-frequency current to flow through a housing. Here,  $\lambda$  is representative of the wavelength of a signal used. On the other hand, the antenna 14 is

implemented with an antenna which, although lower in gain than a sleeve or whip antenna, can be built in a housing like a flat antenna.

So far as gain is concerned, both of the antennas 14 and 15 should preferably comprise a sleeve antenna or a  $\lambda/2$  whip antenna. However, when it comes to portability and design, mounting two such antennas on a housing is problematic. For example, a  $\lambda/2$  whip antenna has an element length which is substantially 16 cm for the frequency band of 900 MHz, mounting two antennas each having such a length on a housing being impractical. On the other hand, the exclusive antenna 15 for reception preserves the diversity effect even if the gain is lowered by about several dB compared to the transmit/receive antenna 14 and, therefore, it can be implemented with a flat antenna. Further, not only the space diversity effect but also the polarization diversity effect can be expected if a flat antenna is used in combination with a vertical polarization antenna of a sleeve antenna or that of a  $\lambda/2$  whip antenna.

For the above reason, applying a built-in antenna to a portable radio communication apparatus in combination with the sleeve or whip antenna of Fig. 1 is advantageous, and actually this combination is used in the present invention. However, the construction shown in Fig. 1 has a drawback that when the sleeve or whip antenna is tucked away, the apparatus becomes unable to transmit, as previously stated. Specifically, when the antenna 14 is received in the housing, the gain is lowered to a value which is even far smaller than that of the built-in antenna 15 and, in the worst case, the antenna 14 is electrically isolated to make transmission impossible. Hence, the prior art apparatus shown in Fig. 1 is not applicable to a system in which a transmission should begin automatically in response to a reception.

Referring to Fig. 2A, a portable radio communication apparatus embodying the present invention is shown in a block diagram. In the figure, a first antenna 1 is implemented with a sleeve or whip antenna which may be received in a housing 13 of the apparatus or folded, as described in detail later. The antenna 1 protrudes from the housing 13 unless tucked in or folded. In this particular embodiment, the antenna 1 is assumed to be bodily received in the housing 13. A second antenna 2 is implemented with a microstrip or like flat antenna which is built in the housing 13 or mounted on the outer periphery of the housing 13 so as not to protrude from the housing 13.

When the first antenna 1 is received in the housing 13 as shown in Fig. 2A, it is electrically disconnected from a first switch 5. By the movement of the first antenna 1 into the housing 13, the first switch 5 is automatically caused to shift an antenna terminal 9 of a duplexer 8 from the first antenna 1 to the second antenna 2. In this instance, a second switch 6 which is interlocked with the first switch 5 maintains a reception filter 10 disconnected from the second antenna 2, the receive frequency band being the pass band of the filter 10. Specifically, when the first antenna 1 is received in the housing 13, the switches 5 and 6 are actuated such that the second

or built-in antenna 2 becomes connected to a transmitter 12 via a transmission filter 81 and to a diversity receiver 11 via a reception filter 82.

In Fig. 2B, the apparatus of Fig. 2A is shown in a condition wherein the first antenna 1 is pulled out of the housing 13 to its outermost position. As shown, since contacts 3 and 4 are brought into connection, the first antenna 1 is connected to the switch 5. The switch 5 is operated to connect the first antenna 1 to the antenna terminal 9 of the duplexer 8 while disconnecting the second or built-in antenna 2. The second switch 6, on the other hand, is actuated to connect the built-in antenna 2 to the diversity receiver 11 via the reception filter 10. In short, when the first antenna 1 is held in the outermost position, the antenna 1 is shared by transmission and diversity reception while, at the same time, the second or built-in antenna 2 is exclusively assigned to diversity reception.

In the condition shown in Fig. 2B, a line 7 extending between the first and second switches 5 and 6 is connected to the antenna 2 and, therefore, apt to disturb high-frequency matching. Such an occurrence can be eliminated by dimensioning the line 7 sufficiently short for  $\lambda/4$  or equal to an integral multiple of  $\lambda/2$  of the receive frequency band.

Referring to Figs. 3A and 3B, an essential portion of a second embodiment of the present invention is shown. The second embodiment has the same structure as the first one of Figs. 2A and 2B except that a switch 106 having three contacts is used in the second embodiment in place of the switch 6 having two contacts. The conditions shown in Figs. 3A and 3B correspond to those of Figs. 2A and 2B, respectively. In Fig. 3A, the first antenna 1 is disconnected from the terminal 9 of duplexer 8 while the second or built-in antenna 2 is connected to the transmitter 12 and the diversity receiver 11 through the duplexer 8. On the other hand, in Fig. 3B, the first antenna 1 is connected to the transmitter 12 and the diversity receiver 11 through the duplexer 8 while the second antenna 2 is connected to the diversity receiver 11 through the reception filter 10.

Unlike the connecting line 7 of Fig. 2B, a connecting line 107 is disconnected from the second antenna 2 in the condition shown in Fig. 3B. Accordingly, the line 107 has no adverse effect on the high-frequency matching. In other words, the length of line 107 can be freely selected.

Referring to Fig. 4, there is shown an illustrative and not limitative mechanism for automatically actuating the switches 5 and 6 or 106 in response to the movement of the first antenna 1 into and out of the housing 13. As shown, while the first antenna 1 is fully or partly received in the housing 13, a lever 16 is urged by a spring 20 to the position shown in the figure. As the antenna 1 is pulled out to the outermost position, the conductor 3 fixed to the bottom of the antenna 1 is brought into connection with the contact 4 while rotating the lever 16 about a pin 17 against the action of the spring 20. Then, the lever 16 presses actuators 18 and 19 which are respectively associated with the switches 5 and 6 or 106, whereby the switches 5 and 6 or 106 are actuated as explained with reference to Figs. 2A and

2B or 3A and 3B.

Figs. 5 to 7 show exemplary configurations of the first antenna 1. In Fig. 5, a sleeve antenna 41 serves as the first antenna 1 and may be fully received in the housing 13. In Fig. 6, a whip antenna 51 is shown which also serves as the first antenna 1 and may be fully received in the housing 13. In Fig. 7, a whip antenna 61 plays the role of the first antenna 1 and is foldable along the outer periphery of the housing 13.

In summary, it will be seen that the present invention provides a portable radio communication apparatus in which, when a sleeve antenna or a whip antenna is pulled out of a housing of the apparatus, a sufficient gain is attainable due to the gain of that antenna and diversity reception by that antenna and a built-in antenna. Another advantage of the present invention is that even when the sleeve or whip antenna is tucked away in the housing, the built-in antenna is automatically switched from a receive-only condition to a transmit and receive condition to allow transmission and reception to be performed as needed. Hence, even in a system in which an answer to a reception is automatically transmitted and, then, a communication is allowed only if the answer is confirmed by the other party, a person can wait for a reception while carrying the apparatus in a bag or the like with the antenna not protruded from the housing. In addition, in a place where an electric field which allows stable connection to be set up through the built-in antenna only and, yet, without resorting to reception diversity is available, communication may be performed with the sleeve or whip antenna kept in the housing, i.e., in an easy-to-use condition wherein no long projections exist.

## Claims

1. A portable radio communication apparatus comprising:

transmitter means;  
diversity receiver means;  
transmission filter means connected to said transmitter means;  
first and second reception filter means connected to said diversity receiver means;  
first antenna means capable of being received in a housing of said apparatus;  
second antenna means mounted inside of or on outer periphery of said housing; and

switch means for connecting said second antenna means to a junction of said transmission filter means and first reception filter means in a first condition in which said first antenna means is received in said housing, and connecting said first antenna means to said junction and said second antenna means to said second reception filter means in a second condition in which said first antenna means is pulled out of said housing.

2. An apparatus as claimed in claim 1, wherein said switch means comprises a first and a second switch which are interlocked with movement of said first antenna means into and

out of said housing;

said first switch, in the first condition, disconnecting said first antenna means from said junction while connecting said second antenna means and, in the second condition, disconnecting said second antenna means from said junction while connecting said first antenna means;

said second switch, in the first condition, disconnecting said second antenna means from said second reception filter means and, in the second condition, connecting said second antenna means to said second reception filter means.

3. An apparatus as claimed in claim 2, wherein a line extending between said first and second switches has a length which is shorter than  $\lambda/4$ , where  $\lambda$  is a wavelength of a received signal.

4. An apparatus as claimed in claim 2, wherein a line extending between said first and second switches has a length which is an integral multiple of  $\lambda/2$ , where  $\lambda$  is a wavelength of a received signal.

5. An apparatus as claimed in claim 1, wherein said first antenna means comprises a sleeve antenna.

6. An apparatus as claimed in claim 1, wherein said first antenna means comprises a whip antenna.

7. An apparatus as claimed in claim 1, wherein said second antenna means comprises a microstrip antenna.

8. A portable radio communication apparatus comprising:

first antenna means capable of selectively assuming a first condition wherein said first antenna means does not protrude from a housing of said apparatus, and a second condition wherein said first antenna means protrudes from said housing;

second antenna means supported by said housing in such a manner as not to protrude from said housing;

transmitter means;  
diversity receiver means; and

switch means for, in the first condition, connecting said second antenna means to said transmitter means and diversity receiver means and, in the second condition, connecting said first antenna means to said transmitter means and diversity receiver means while connecting said second antenna means to said diversity receiver means.

9. An apparatus as claimed in claim 8, wherein said switch means comprises a first and a second switch which are actuated in response to a change of condition of said first antenna means;

said first switch, in the first condition, disconnecting said first antenna means from said transmitter means and diversity receiver means while connecting said second antenna means and, in the second condition, connecting said first antenna means to said transmitter

means and diversity receiver means while disconnecting said second antenna means;

said second switch, in the first condition, disconnecting said second antenna means from said diversity receiver means and, in the second condition, connecting said second antenna means to said diversity receiver means.

10. An apparatus as claimed in claim 9, further comprising a transmission filter connected to said transmitter means;

a first reception filter connected to said diversity receiver means, said transmission filter and first reception filter being connected to each other, a junction of said transmitter filter and first reception filter being connected to said first switch; and

a second reception filter connected between said second switch means and said diversity receiver means.

11. An apparatus as claimed in claim 10, wherein a line extending between said first and second switches has a length which is shorter than  $\lambda/4$ , where  $\lambda$  is a wavelength of a received signal.

12. An apparatus as claimed in claim 10, wherein a line extending between said first and second switches is an integral multiple of  $\lambda/2$ , where  $\lambda$  is a wavelength of a received signal.

13. An apparatus as claimed in claim 8, wherein said first antenna means comprises a sleeve antenna which is received in said housing in the first condition and pulled out from said housing in the second condition.

14. An apparatus as claimed in claim 8, wherein said first antenna means comprises a whip antenna which is received in said housing in the first condition and pulled out of said housing in the second condition.

15. An apparatus as claimed in claim 8, wherein said first antenna means comprises a whip antenna which is folded along outer periphery of said housing in the first condition and unfolded to stand on said housing in the second condition.

16. An apparatus as claimed in claim 8, wherein said second antenna means comprises a microstrip antenna which is built in said housing.

17. A portable radio communication apparatus having:

a first antenna capable of being received in a housing of said apparatus;

a second antenna disposed in said housing or on outer periphery of said housing;

a duplexer; and

a reception filter having a pass band which is a receive frequency band;

in a condition wherein said first antenna is pulled out of said housing, an antenna terminal of said duplexer and said reception filter being connected to, respectively, said first and second antennas for effecting reception diversity;

said apparatus comprising:

a first switch for switching said antenna terminal of said duplexer from said first antenna

to said second antenna when said first antenna is received in said housing; and

a second switch for disconnecting said reception filter from said second antenna interlocked with said first switch.

18. A method of switching a first antenna of a portable radio communication apparatus, which includes a transmitter and a diversity receiver, capable of assuming a first condition wherein said first antenna does not protrude from a housing of said apparatus and a second condition wherein said first antenna protrudes from said housing, and a second antenna supported by said housing in such a manner as not to protrude from said housing, said method comprising the steps of:

in the first condition, connecting said second antenna to said transmitter and diversity receiver; and

in the second condition, connecting said first antenna to said transmitter and diversity receiver while connecting said second antenna to said diversity receiver.

19. A method as claimed in claim 18, wherein connection of said second antenna to said transmitter and diversity receiver in the first condition and connection of said first antenna to said transmitter and diversity receiver in the second condition are performed through, respectively, a transmission filter and a first reception filter, and connection of said second antenna to said diversity receiver in the second condition is performed through a second reception filter.

20. A method as claimed in claim 18, wherein connection of said first and second antennas to said transmitter and diversity receiver occurs in response to a change of condition of said first antenna from one to the other of said first and second conditions.

21. A method as claimed in claim 18, wherein said first antenna is received in said housing in the first condition and pulled out of said housing in the second condition.

22. A method as claimed in claim 18, wherein said first antenna means comprises a whip antenna which is received in said housing in the first condition and pulled out of said housing in the second condition.

23. An apparatus as claimed in claim 18, wherein said first antenna means comprises a whip antenna which is folded along outer periphery of said housing in the first condition and unfolded to stand on said housing in the second condition.

24. An apparatus as claimed in claim 18, wherein said second antenna means comprises a microstrip antenna which is built in said housing.

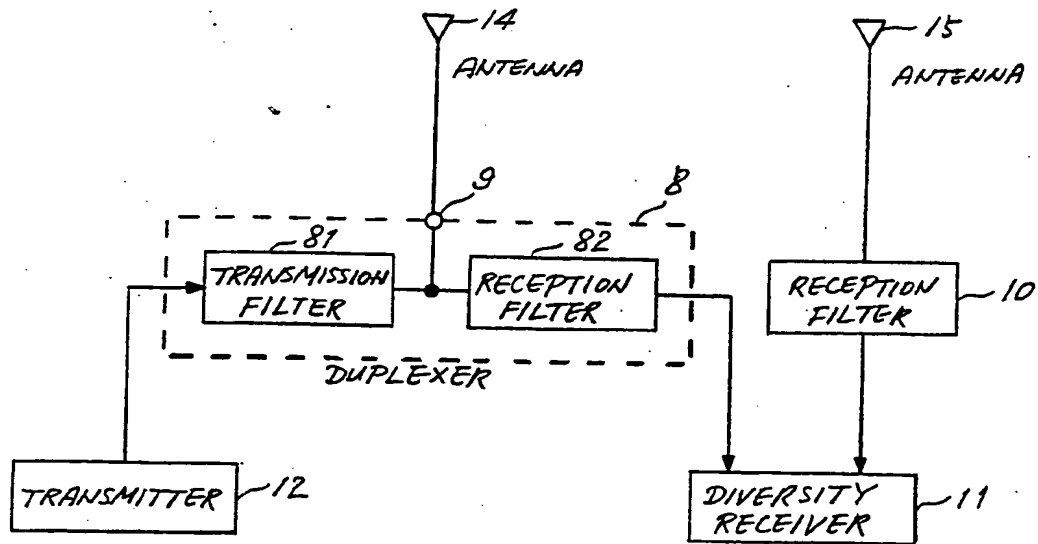


Fig. 1 PRIOR ART

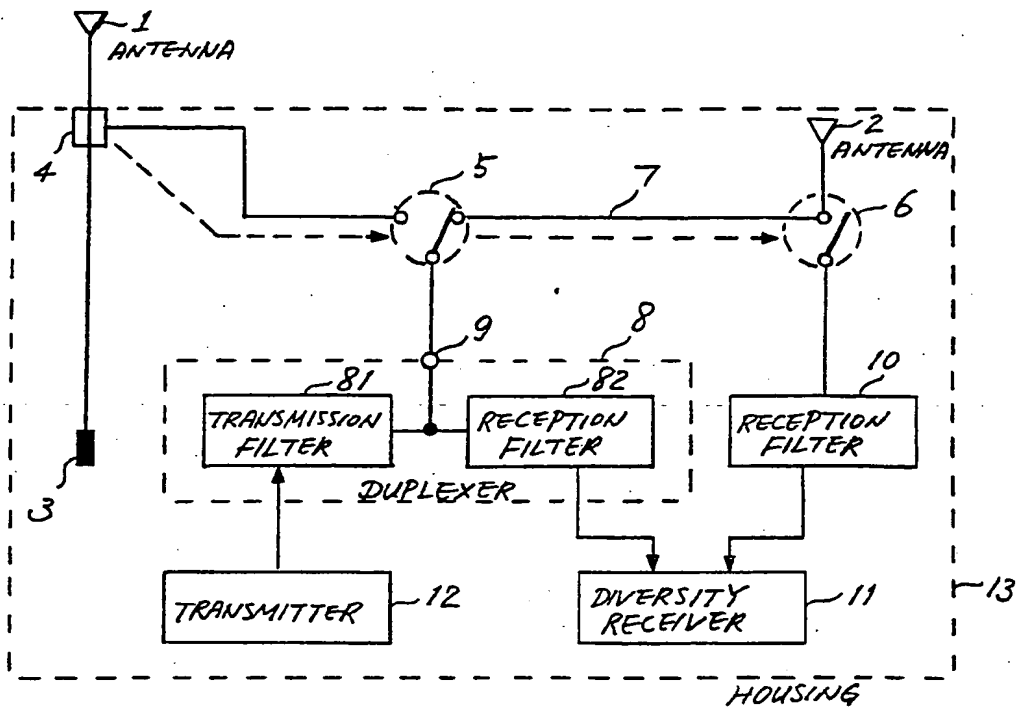


Fig. 2A

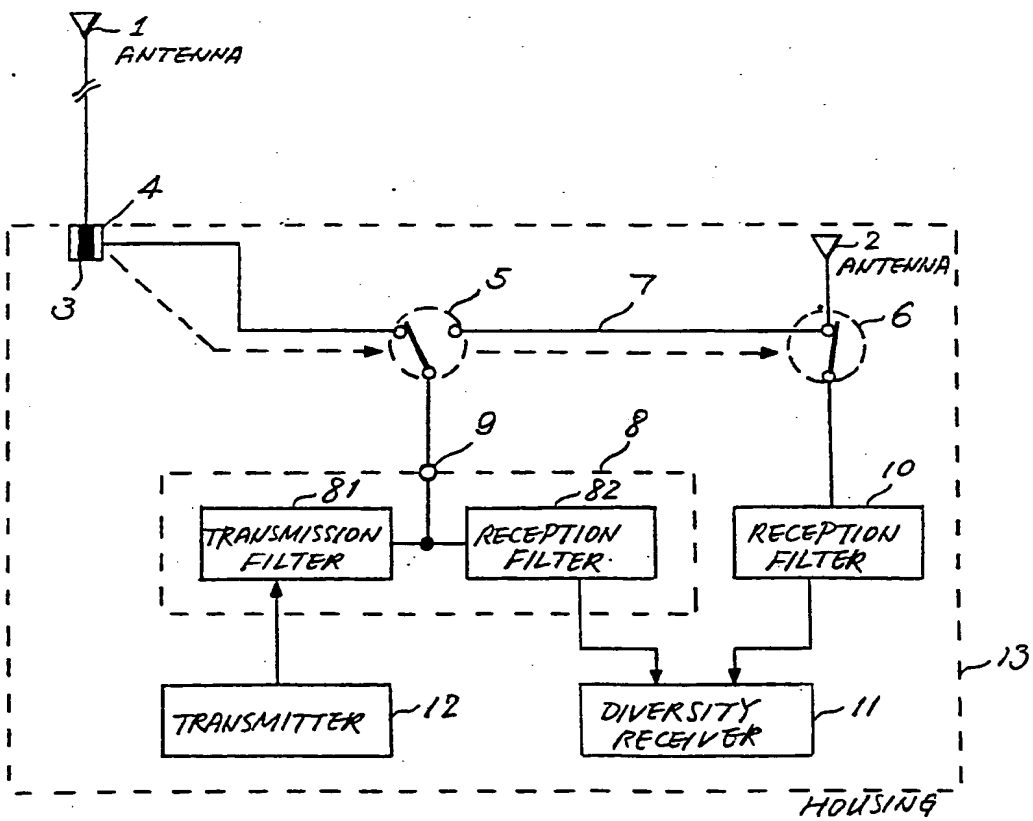


Fig. 2B

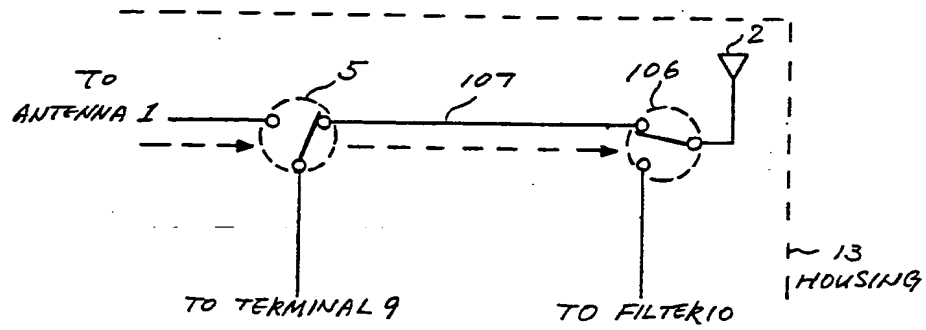


Fig. 3 A

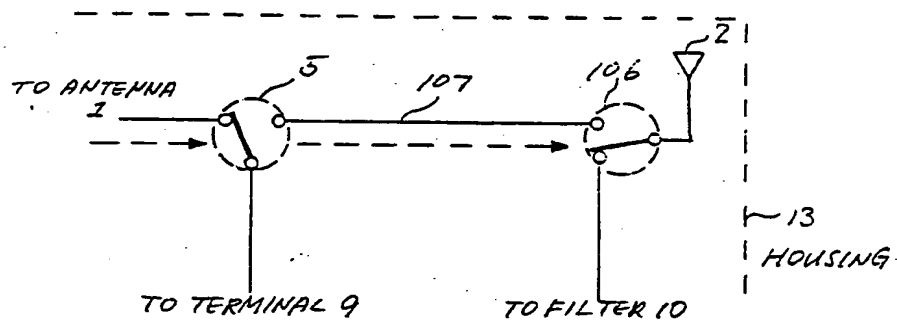
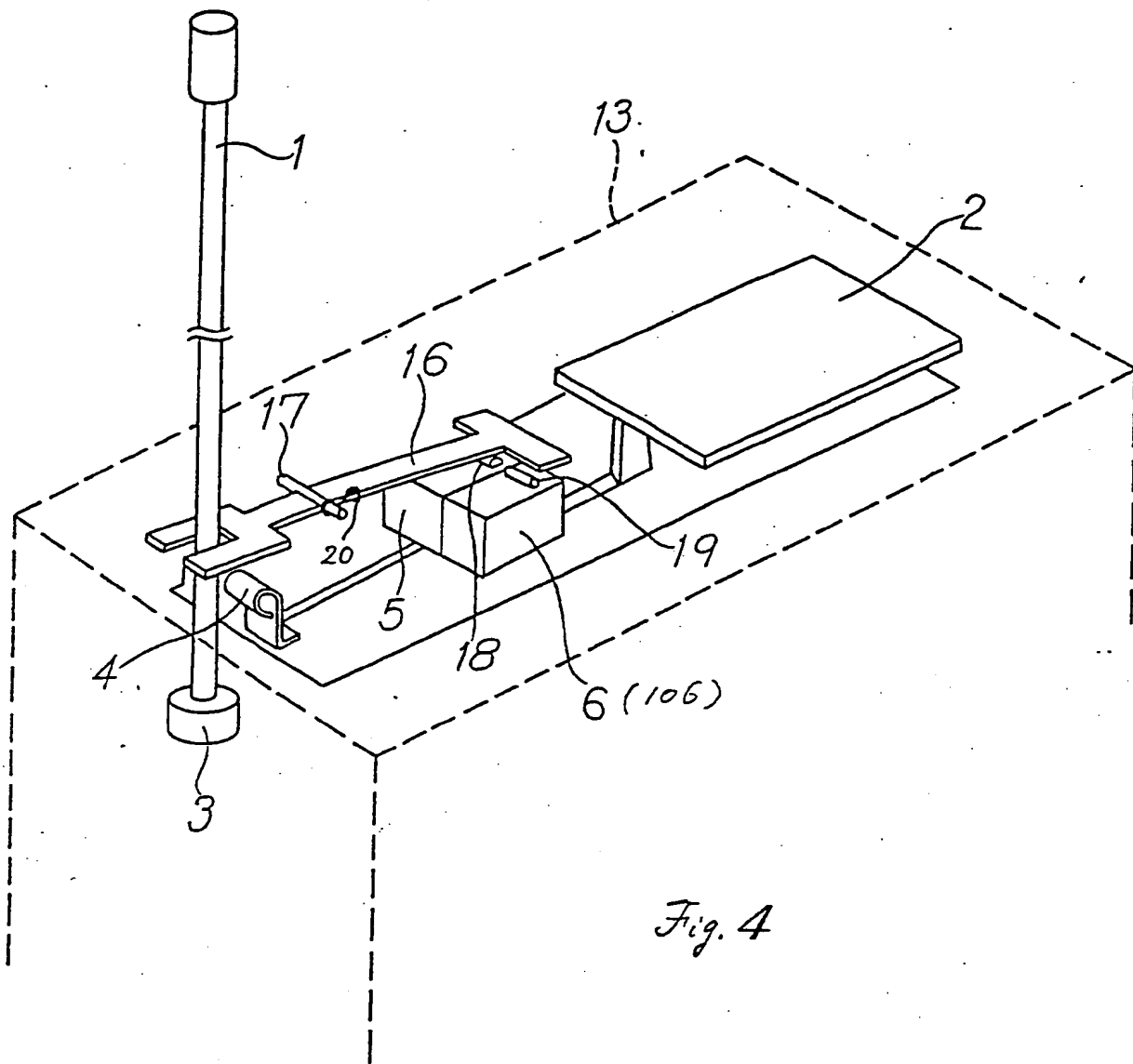
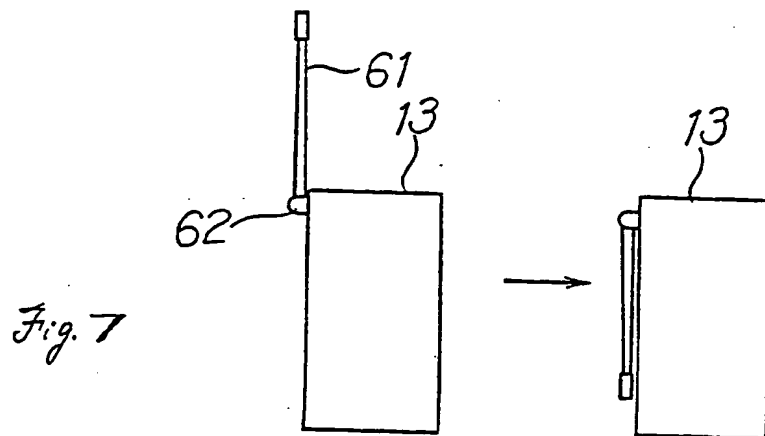
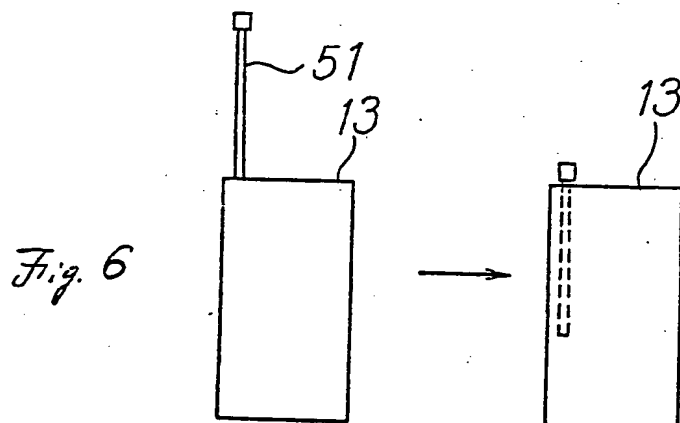
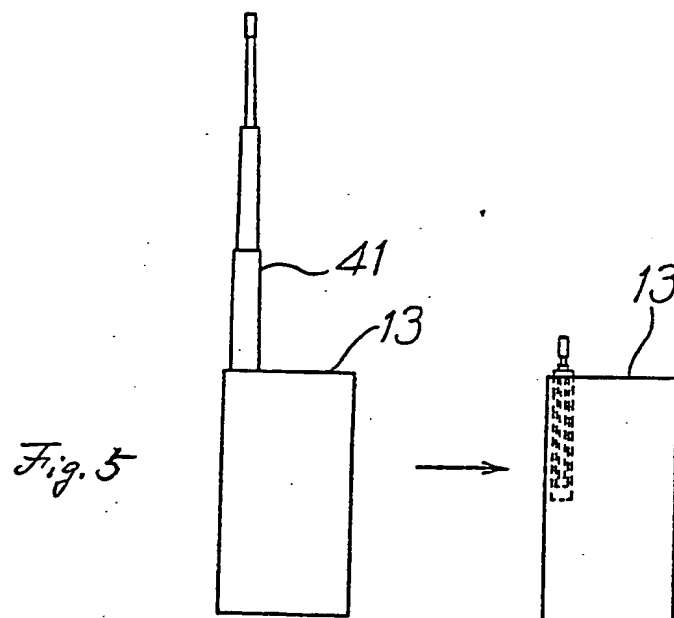


Fig. 3 B







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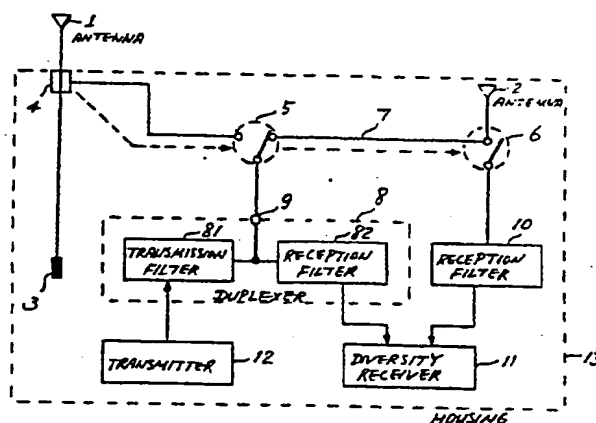


Fig. 2A

EP 0 259 129 A3



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number

EP 87 30 7679

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-4 313 119 (GARAY et al.) * Column 4, line 33 - column 5, line 24; figures 6-9 *	1,2,6,8 ,14,15, 17,18, 20-23	H 04 B 7/08 H 04 B 1/38
A	WO-A-8 500 480 (MOTOROLA) * Page 7, line 24 - page 8, line 3; page 6, line 34 - page 7, line 7; page 15, lines 34-36; abstract *	1,8,17, 18	
P,A	US-A-4 633 519 (A. GOTOH) * Column 2, lines 4-8,42-65; figure 3 * & JP-A-59 181 732 (TOKYO SHIBAURA) (Cat.A)	1,6-8, 14-18	
A	FR-A-2 514 972 (SONY) * Page 4, line 21 - page 5, line 12; figure 1 *	1,2,8,9 ,17,18	
P,A D	EP-A-0 214 806 (NEC) * Abstract; page 7, paragraph 2; figure 1B, claims 1-3 *	1,5-8, 10,13- 24	TECHNICAL FIELDS SEARCHED (Int. Cl.4)  H 04 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 09-03-1989	Examiner SNELL T.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document  T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons  & : member of the same patent family, corresponding document			

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